FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
BERKELEY - CALIFORNIA

MISCELLANEOUS PAPER

No. 62 November 1961

HELICOPTER SOWING OF BURNED WATERSHEDS ON THE SAN DIMAS EXPERIMENTAL FOREST, 1960

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Helicopters have proved well adapted for sowing seed to establish a temporary herbaceous cover on burned chaparral watersheds in southern California. Fixed-wing aircraft can sow large acreages rapidly and cheaply, but the helicopter has the advantage that it can do close, careful work in steep terrain with a high degree of pilot safety. Sowing by helicopter was the only feasible method of spreading seed on the San Dimas Experimental Forest after it was burned by wildfire in July 1960. Ground equipment could not be used on the steep terrain, and fixed-wing aircraft would not allow the control of seed distribution needed for experimental purposes. Many small areas were sown with a variety of species in various combinations. Other areas were left unsown as experimental checks. The procedures developed during this complex sowing operation can help guide other kinds of aerial broadcast sowing jobs.

PROCEDURES AND COSTS

A total of 13,496 acres were sown in 132 individual areas: 70 small watersheds and linear plots of 3 to 26 acres each; 18 intermediate areas of 26 to 103 acres each; and 44 larger areas, averaging 254 acres each.

Grasses were sown at 10 pounds per acre on most of the acreages, and mustard at 5 pounds per acre on a few areas. The helicopter flying was contracted for approximately $70.00 per hour of actual flight time.

The average cost per acre for each phase of the sowing operation was:

Marking areas	0.04
Hauling seed	0.05
Loading seed	0.14
Keeping records	0.07
Helicopter flying	0.83
Total	$1.13

The cost of each phase naturally was higher for the small areas than for the larger operational units. Average costs per acre for areas of different sizes were approximately $2.00 for small areas, $1.50 for intermediate areas, and $1.00 for the larger areas.

These costs include all equipment operation and all salaries except those of technical project men who planned and directed the work. Costs for purchase of seed and for seed storage and mixing are not included.

NUMBERING AND MARKING AREAS

Each sowing area was outlined on a large-scale planning map and numbered as soon as its specific treatment had been decided. The areas were numbered consecutively as the planning progressed. A duplicate of the map was used in the field to direct the sowing operation. All areas to be left unsown as experimental controls were colored yellow on the map as a constant caution not to fly over them.

The acreage, species to be sown, rates of sowing, and total seed requirements were tabulated for each area. Copies were used by the project planner, the seed mixing crew, and the man who directed all of the helicopter flying. This detailed procedure made it possible to sow the many areas as planned with only a few minor mistakes.

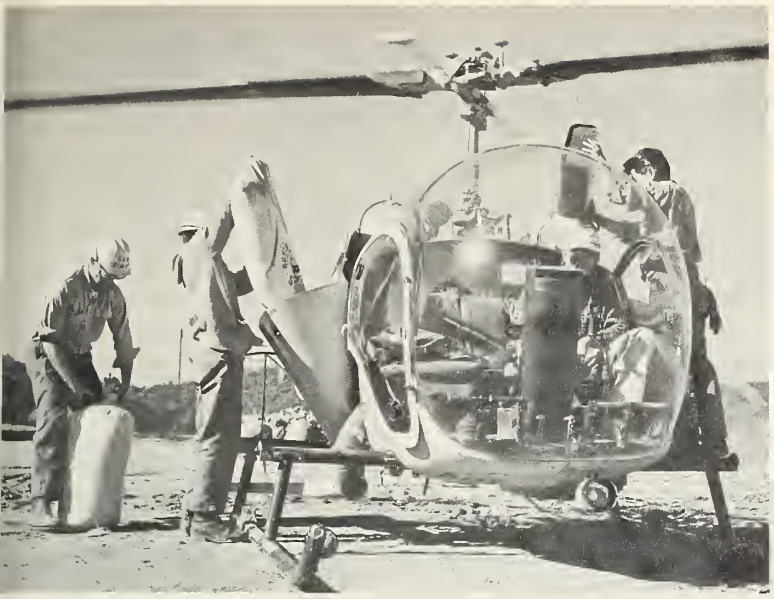
Boundaries of areas to be left unsown were marked by dropping small paper bags of lime which burst on contact with the ground and left readily visible markers. The boundaries of areas to be sown were similarly marked during reconnaissance flights just ahead of sowing. Some markers were eliminated by rain and had to be replaced.

The small experimental areas were surveyed and staked ahead of sowing, and the boundaries marked with flags. One or more flagmen guided the helicopter pilots during sowing to make sure the correct areas were sown. The intermediate and large areas were sown without flagmen.

HANDLING AND MIXING SEED

All of the seed was delivered to the experimental forest and stored until inspected for compliance with county seed laws. The seed was mixed at this location instead of at a mill because of the numerous mixtures to be used and the necessity for planning treatments after the seed had been delivered.

The work in handling and storing the seed in bulk was done by a Conservation Camp crew furnished by the California State Division of Forestry. They weighed, mixed, and bagged the simple mixtures of 2 species which were used in large quantity. Crews of 4 men under the direction of a technician mixed the more complex mixtures. A crew of this size could put together a mixture of 4 species at the rate of about 4,000 pounds a day. Mixtures containing more species were time-consuming and would not be practical for mixing in large quantities. However,



Loading and refueling the helicopter.

Helicopter landing at a temporary heliport.

Catching seed in sack, with seed distributor removed, during calibration of the seeder.

hand mixing proved feasible for simple mixtures if only 100 to 200 pounds of seed were mixed at a time.

The seed was bagged in 50-pound lots for ease in hauling and in loading the helicopter. Each bag of seed covered 5 acres. Rice hulls were mixed with the seed sown on the small and intermediate experimental areas, to bring each bag of seed up to a uniform volume. This made it possible to sow the various seed mixtures without constant recalibration of the seeders. For the seed sown on the large areas, however, rice hulls were not added because a test showed that the most complex mixtures were evenly distributed without the hulls (Edmunson, et al., 1961).

The best volume of seed and rice hulls per bag was determined by trial. A 20-gallon volume proved too small because this volume of seed for 8 of the species weighed less than 50 pounds (table 1). A 25-gallon volume per bag was adequate for all of the mixtures that were used, even though seed of 3 species weighed less than 50 pounds in 25-gallon lots. Blando brome was the only species with seed weighing appreciably less than 50 pounds per 25 gallons. Seed of this species presented other difficulties in sowing because it did not flow freely through the seeders. Where it was sown alone in plot trials, the desired rate was obtained by flying twice over the plot.

The amount of rice hulls to add to seed of an individual species or mixture to bring it to a given volume can be estimated from the data in table 1. For example, in a 50-50 mixture of Hardinggrass and tall wheatgrass at 25 gallons per 50 pounds of seed, add 10 pounds (.50 x 20) of hulls for the Hardinggrass and 1 pound (.50 x 2) for the wheatgrass, making a total of 11 pounds of hulls, which is the same amount determined by trial. In a 70-30 mixture of ryegrass and mustard, add 7.7 pounds (.70 x 11) of hulls for the ryegrass and 6.3 pounds (.30 x 21) for the mustard, making a total of 14.0 pounds. For some mixtures, however, the calculated amount of rice hulls to be added may not be so exact because seeds of various sizes and shapes may combine differently with the rice hulls, and rice hulls do not have a constant weight per unit of volume.

A crew of 5 men for hauling seed and loading the helicopter kept the operation moving smoothly. Most of the loading was done by two men. When sowing was interrupted by inclement weather the crew built heliports or helped mix seed.

OPERATING THE HELICOPTERS

The helicopters were flown from ten heliports located adjacent to roads and well situated for safe and efficient landing and take-off. Each heliport was of sufficient size for servicing and operating two helicopters and for storage of two truckloads of seed. Each landing pad was on a cleared area of at least 60 feet diameter. A strip of bright-colored tape on an iron rod close by the pads served as a wind indicator.

Table 1.--Approximate weights of seed and rice hulls in bags of 20 and 25 gallon volume, for different species and mixtures

Species or mixture	Volume of bag			
	20 gallons		25 gallons	
	Seed	Hulls	Seed	Hulls
	Pounds			
Ryegrass	50	6	50	11
Blando brome	31	0	38	0
Ryegrass 4 1/, Blando 1	50	0	50	6
Black mustard	50	15	50	21
Ryegrass 7, mustard 3	50	7	50	14
Tall wheatgrass	42	0	50	2
Pubescent wheatgrass	37	0	46	0
Intermediate wheatgrass	43	0	50	1
Hardinggrass	50	14	50	20
Harding 1, tall wheatgrass 1	50	6	50	11
Smilo	50	19	50	27
Veldtgrass	40	0	50	5
Veldt 1, tall wheatgrass 1	41	0	50	3
Tall fescue	50	3	50	8
Orchardgrass	44	0	50	2
Big bluegrass	39	0	48	0
Rose clover	50	18	50	24
Rose 1, tall wheatgrass 1	50	8	50	13
Subterranean clover	50	16	50	22
Woolypod vetch	50	15	50	21

1/ Numerals indicate parts by weight.

Most of the sown acreage was within a mile of a heliport--an important factor in keeping down the cost of sowing by helicopters, which carry relatively small loads. For the 200-pound seed loads commonly carried in this operation, flight time to and from the sowing areas within 1 mile cost about 3 to 15 cents per acre. The cost was 35 to 40 cents for areas 3 miles away, and would have been more than 60 cents if areas were located 5 miles from the heliport. On non-research jobs, flight-time costs might be reduced by decreasing the sowing rate per acre or by covering more acres per load.

Sowing of small experimental areas required extra reconnaissance flights and ferry flights between heliports. Also extra flight time was required for sowing, mainly because of short swaths and light loads. The average costs per acre of different kinds of flights for areas of different sizes were:

Size of Area	Kind of Flight			
	Sowing	Reconnaissance	Ferry	Total
Small	$ 1.20	$ 0.13	$ 0.09	$ 1.42
Intermediate	0.99	0.08	0.16	1.23
Large	0.67	0.05	0.02	0.74

Two helicopters could be operated simultaneously from a heliport if a different sowing area were assigned to each pilot and separate flagmen stationed at each area.

The seeder attached to each side of a helicopter included a 50-gallon hopper, a wire agitator in the bottom of the hopper, a shut-off gate, and a blower. The agitator, gate, and blower were operated by three separate motors. The rate of seed movement from the hopper was regulated by a notched slide which was manually adjusted for each seed mixture. Spread of seed from the blower was guided by a flat, fan-shaped distributor.

The seeders were calibrated many times because of changes in seed mixtures, or moves from large areas to small plots. To calibrate a seeder, a full bag of seed was placed in the hopper and the distributor removed from the blower. The slide was set at an estimated point. With the agitator and blower operating, the rotor was revved up to flight RPM and the seed was caught in a sack behind the blower while the gate was opened for a given period of time. The slide was readjusted and the process repeated until the correct amount of seed was caught from each seeder. The correct amount of seed to catch from each seeder during a 30-second run was 10 pounds for a rate of 10 pounds per acre sown in 40-foot swaths at a 45 mile per hour flying speed, as used in the sowing operations. For a 50-pound bag of seed containing an additional 5 pounds of rice hulls, the correct amount to catch was 11 pounds of seed and hulls combined.

Weather greatly influenced the speed and efficiency of the sowing operation. During the 37-day period from October 23 to November 29, excessive wind prevented sowing on 4 days and cloudy or rainy weather, often with wind, on 6 additional days. On calm mornings the sowing was started at daybreak and stopped when wind speed reached about 10 miles per hour. Flying usually continued for $2\frac{1}{2}$ to $3\frac{1}{2}$ hours and averaged slightly more than 3 hours per day. The allowable maximum of 6 hours was reached on only one day. Fog which prevented flying of fixed wing aircraft from valley airports did not greatly hamper operations of the helicopters, which were based above 2,000 feet elevation.

A timekeeper recorded the flights of each helicopter from take-off to landing. The log included minutes in the air, amount and kind of seed carried, and the number of the area sown. This intensive record keeping, required under the helicopter contract, made possible a continuous check for mistakes in sowing and a detailed analysis of the helicopter operation at the end of the job.

SUMMARY

From October 23 to November 29, 1960, seed of herbaceous plants was sown by helicopter on 13,496 acres of burned-over chaparral watershed on the San Dimas Experimental Forest. This acreage included 70 small experimental areas of 2 to 26 acres, 18 intermediate areas of 26 to 103 acres, and 44 larger areas. Seed of 15 species was sown in various combinations. Rice hulls were added to the seed for each small and intermediate area to bring each 50-pound bag up to a uniform volume. Cost of the sowing operation, exclusive of seed and seed mixing, was $2.00 per acre for the small areas, $1.50 for the intermediate, and $1.00 for the larger areas. The procedures developed for this complex operation are described as a guide to other helicopter sowing jobs.